TITLE OF THE INVENTION

Unitized Fifth Wheel and Rear Axle Suspension

CROSS REFERENCE TO RELATED APPLICATIONS

None

I. Background of the Invention

1. Field of Invention

A suspension system for short distance repositioning tractors, often referenced as terminal tractors, isolating the shock and impact of a retractable fifth wheel and rear axle from the frame of the terminal tractor by the arrangement of a rear axle and fifth wheel boom having lift cylinders between them and joining the rear axle, a lift arm assembly and a trailing arm assembly as a singular modular unit, isolated from the frame of the terminal tractor by elastomeric bushings at a forward location and pivot point on the terminal tractor frame, with a secondary suspension located at the rear of the singular modular unit.

2. Description of Prior Art

Typically, a terminal tractor has a short wheelbase of between 110 and 116 inches. It is a cab over engine design with a one person cab, offset far to one side of the chassis. It has a medium duty diesel engine with an automatic transmission and a high reduction rear axle, the automatic transmission and the high reduction rear axle allowing the tractor to start and move a heavy load with a relatively low horsepower engine. The terminal tractor is only intended for short haul purposes in a truck depot or a yard where trailers are to be moved for short distances to and from a loading area. The steering axle is suspended from the frame with semi-elliptical leaf springs, while the rear axle is typically solidly mounted to the frame using mounting brackets and large capscrews to secure the

axle. The fifth wheel, used to attach to the trailer, is mounted on a pivoted bracketry, generally referenced as a boom, which raises through hydraulics and lifts a loaded trailer or chassis for a short distance during the transport in the yard or depot.

Current industry standards in suspensions have the rear axle directly mounted to the frame of the tractor. The current standards in boom attachments use steel or bronze bushings rotating on a nominal 2" diameter pivot shaft which floats in round holes in the frame rails, usually called sockets, near the center of the vehicle. Double acting hydraulic cylinders mounted between the frame and the boom provide a 50,000 to 70,000 pound lift capacity at the fifth wheel. Because of the extreme difference in axle weight between the unloaded condition (approximately 4,000 lbs.) of the terminal tractor and the loaded condition (approximately 30,000 lbs.), finding a working suspension that performs under both conditions has been a challenge.

The domestic terminal tractor manufacturers have been trying to develop a dependable working suspension for the rear axle of terminal tractors for several years. In the early 1980s, rubber block suspensions were attempted to cushion the frame from the shocks of ground impacts, but they provided very little flexibility. Since about the middle 1980s, several manufacturers have offered versions of conventional spring suspensions fitted to provide limited flexibility in empty and light load conditions and to settle the frame on rubber bumpers above the axle under heavy load conditions. This system is complex and expensive, but seems to be the best suspension alternative to date. Since 1992, a company named Capacity has offered a rear axle air suspension option, featuring a large A-frame under the chassis, connected to a central frame cross-member approximately below the boom attachment point near the center of the vehicle. The rear axle and lift cylinders attach to the rear ends of the A-frame below the chassis. Air springs between the axle and

the frame allow vertical movement of the rear axle relative to the frame, lift the boom from the A-frame, independent of the chassis, which allows effective isolation of the chassis from vertical movement of the rear axle and boom. A bushed single front attachment of the A-frame suggests allowance of side-to-side rotation of the axle relative to the frame. However, solid mounting of the lift cylinders to the fifth wheel boom, solidly pinned to the frame through a steel pivot shaft and bushings prevents side-to-side suspension rotation and creates extreme high stress loads at the A-frame connection, pivot shaft mountings and bushings. The cost, weight and complexity of this suspension are significant and it has proven to be expensive to maintain and service. This type product accounts for only a small percent of the market.

The following United States patents were discovered and are disclosed within this application for utility patent. In U.S. patent No 6,209,895 to Mueller, an axle suspension is provided for a wheeled vehicle having an axle suspension pivotally engaged with the frame with a rubber bushing acting as cushion along with a shock relating between the frame and rear axle mount. In U.S. Patent No. 6,135,483 to Metz, a fifth wheel suspension system is disclosed wherein the frame has three separate pivotal mounting locations, having a first pivotal mount located between the frame and a rear axle support arm having an attached rear axle, with a bushing for a cushion and a shock, similar to Mueller, supra. This suspension system also contains pivotal mountings between the frame and two fifth wheel lift arms, with a hydraulic cylinder between the rear axle support arm and the base of the fifth wheel. This still relates shocks of the rear axle directly to the fifth wheel and also to the three pivotal connections to the frame.

Several patents use air suspension systems in a variety of pivotal mounting mechanisms for fifth wheels, including U.S. Patents No. 2,821,409 to Chalmers, 3,380,758 to Granning, 5,388,849

to Arsenault, 4,279,430 to Tagg, and 5,639,106 to Vitale. Those using rubber bushings for cushion between related pivotal components having fifth wheel application included U.S. Patents No. 4,162,799 to Willetts, 5,346,247 to Snyder and 5,655,788 to Peaker. None of the suspension systems include a singular pivot point between the frame, the rear axle and the fifth wheel boom which singularly isolate the frame from the rear axle and the fifth wheel boom, yet provide a secondary suspension between the frame and the fifth wheel boom under heavy load as well as a no-load situation.

Summary of the Present Invention

The unitized fifth wheel and rear axle suspension provides a completely new approach to isolating and protecting the chassis from ground impacts and road shocks for terminal tractors and other tractor applications. Recognizing the inherent relationship between the rear axle and a fifth wheel boom on adjustable height fifth wheel vehicles with lift cylinders between them, the unitized suspension joins the rear axle, a boom assembly and a trailing arm suspension assembly as a single modular unit. This unit is isolated from the frame of the terminal tractor by specialized elastomer pivot bushings at the forward location and pivot point. It is also suspended at a secondary location at the rear of the frame by a choice of suspension mechanisms including a single transverse leaf spring, two longitudinal leaf springs, two coiled springs with a track bar or two air springs with a track bar. The transverse leaf spring is the secondary suspension mechanism most discussed in the preferred embodiment.

The primary objective of the unitized suspension is to provide enhanced protection to the terminal tractor chassis from ground impacts and road shocks under both loaded and unloaded conditions. A second objective of the unitized suspension is to provide a single pivot engagement

between the frame, the rear axle, lift arm assembly and trailing arm suspension of the unitized suspension, with a secondary suspension between the unitized suspension assembly and the frame. A third objective of the unitized suspension is to isolate the lift mechanism from the chassis frame by placing the lift mechanism between the rear axle and the lift arm assembly without direct attachment to the frame.

III. Description of the Drawings

The following drawings are submitted with this utility patent application.

Figure 1 is a side view of the lift arm assembly and fifth wheel plate.

Figure 2 is a top view of the lift arm assembly and fifth wheel plate.

Figure 3 is a side expanded view of the trailing arm assembly and rear axle.

Figure 4 is a side view of the trailing arm assembly.

Figure 5 is a side view of the trailing arm assembly and lift arm assembly connected together as the modular suspension system with the hydraulic lift arm fully raised..

Figure 6 is a top view of the trailing arm assembly.

Figure 7 is a top view of the lift arm assembly and the trailing arm assembly attached to the frame of a terminal tractor.

Figure 8 is a rear view of the lift arm assembly in a lowered position and trailing arm assembly attached to the frame of a terminal tractor with phantom lines showing the tractor tires attached to the rear axle.

Figure 9 is a rear view of the lift arm assembly in a fully raised position and trailing arm assembly attached to the frame of a terminal tractor with phantom lines showing the tractor tire attached to the rear axle.

IV. Description of the Preferred Embodiment

A modular suspension system **10** adapted to a terminal tractor having a frame **600**, shown in FIGS. 1-9 of the drawings, comprises a lift arm assembly **100** having a fifth wheel plate **300**, a trailing arm assembly **200** attaching to a rear axle **500**, the trailing arm assembly **200**, having a front segment **202** and a rear segment **204**, having the front segment **202** pivotally connecting to the frame **600** of the terminal tractor at two pivot bushing socket tubes **610** housing elastomeric trailing arm pivot bushings **210** which rotate on a common axis, with the elastomeric trailing arm bushings **210** holding an enforced longitudinal position of the trailing arm assembly **200** while allowing limited vertical movement and side-to-side rotation of the trailing arm assembly **200** relative to the frame **600.** The lift arm assembly **100**, which includes a front segment **102** and a rear segment **204**, is joined at the front segment **102** to the trailing arm assembly **200** by two larger diameter composite bushings **110** rotating on the outer surface of the pivot bushing socket **212** of the elastomeric trailing arm pivot bushings **210**, the elastomeric trailing arm pivot bushings **210** isolating the trailing arm assembly **200** and the lift arm assembly **100** from the frame **600**, with at least one lift cylinder **400** forcing the lift arm assembly **100** from the trailing arm assembly **200** to forcibly elevate and lower the lift arm assembly **100** and the fifth wheel plate **300.** The at least one lift cylinder may be a hydraulic cylinder, a pneumatic lift device or mechanical lift device, but is shown in FIGS. 5 and 9 as hydraulic cylinders.

The trailing arm assembly **200**, shown in FIGS. 3-6, includes a rear portion **220** which supports bracketry, preferably two end housings **222** behind the rear axle **500** which secure ends **272** of a spring means **270** having a center **273**, preferably a transverse leaf spring **274** having two ends **275** and a center **277.** The transverse leaf spring **274** stabilizes the side to side location of the rear axle **500** and the lift arm assembly **100** and provides controlled vertical and side to side rotational

movement, with the spring means **270** or transverse leaf spring **274** being adjusted to a preferred ride character.

The trailing arm assembly **200** also mounts a lower lift cylinder mount **410** of the at least one lift cylinder **400** at a lift cylinder mounting attachment **290** positioned in front of the rear axle **500.** Preferable would be the use of two lift cylinders **400** in tandem, as shown in FIG. 9. The lift cylinder **400** has an upper lift cylinder mount **420** which is pivotally mounted to a lift cylinder mounting attachment **152** in the lift arm assembly **100** in front of the fifth wheel plate **300**. The lift cylinder **400**, when activated, extends, raising the rear segment **104** of the lift arm assembly **100** and the fifth wheel plate **300**, further lifting a trailer or chassis attached to the fifth wheel plate **300**, transferring the lifting forces to the lift arm assembly **100** and trailing arm assembly **200** and isolating these forces from the frame **600** of the terminal tractor by the composite bushings **110**, the elastomeric trailing arm bushings **210** and the spring means **270.**

The lift arm assembly **100**, shown in FIGS. 1-2, 5 and 7, further comprises at least two longitudinal rails **120** connected by at least two lateral rails **130**, each longitudinal rail **120** having a front end **140** and a rear end **150**, the rear end **150** including fifth wheel plate mounting brackets **142** between which is attached the fifth wheel plate **300** by pivot pins **144.** The rear end **150** also includes the lift cylinder mounting attachments **152** located in front of the fifth wheel plate mounting brackets **142**, attaching to the upper lift cylinder mounts **420** of the at least one lift cylinder **400.** The front end **140** includes two pivot bushing housings **160** containing two lower mounting blocks **162** and two upper mounting blocks **164** which respectively attach with endcap retaining bolts **165** to two upper endcap mounting blocks **167** and two lower endcap mounting blocks **169** of two endcaps **166**, within which the composite pivot bushings **110** are secured. The lift arm assembly is further stiffened and

held in desired relation by secure longitudinal and lateral bracing, in this case a welded top plate **125**, which fully encloses the top of the lift arm assembly.

The trailing arm assembly **200**, FIGS. 3 - 4, further comprises two trailing arm beams **230** having a front end **240** and a rear end **260**, each front end **240** having a lower control arm droplink **242** welded to the trailing arm beam **230**, the two trailing arm beams **230** joined at their front ends **240** by a front suspension cross member **262** and reenforced by a corner brace **244**. Each control arm droplink **242** defines a pivot bushing socket tube **246** containing the elastomeric trailing arm bushings **210.** A suspension attaching bolt **248** attaches each elastomeric trailing arm bushing **210** and each composite bushing **110** through the pivot bushing socket tube **246** and also by suspension attaching bolts **248** to suspension attaching bolt tubes **610** in the terminal tractor frame **600.**

The rear end **260** of each trailing arm beam **230** is welded to an axle clamp mounting plate **261** and a trailing arm weldment **266** comprising the rear portion **220** of the trailing arm assembly **200**. An axle clamp weldment **264** is secured to the axle clamp mounting plate **261** by lower clamp bolts **265** and to the rear portion **220** of the trailing arm assembly **200** by end housing retainer bolts **224** and rear cross member retainer bolts **225**. The axle clamp mounting plate **261**, rear axle clamp weldment **264** and trailing arm weldment **266** define a cavity **250** within which the rear axle **500** is secured to the trailing arm assembly **200** and clamped in place by axle clamp bolts **267**, FIGS. 3-4. On an upper surface **268** of each trailing arm weldment **266** is a rear cross member and fifth wheel rest weldment **269** and a spring end housing **222** which secure the preferred transverse leaf spring **274**, FIG. 6. Welded to a lower surface **232** of each trailing arm beam **230** is the cylinder mounting attachment **290** supporting the lower lift cylinder mount **410** of the lift cylinders **400** and a suspension center cross member **263** connecting the two trailing arm beams **230** and supporting the lower lift

cylinder mounting attachments **290**. The end housings **222** within which are secured the ends **275** of the transverse leaf spring **274** attach to the trailing arm weldment **266** by upper clamp bolts **224.** The ends **275** of the transverse leaf spring **274** are captured in the end housings **222** by rubber spring end isolators **276.**

The rear axle **500**, having a pair of dual tractor tires **510** on the ends of the rear axle **500**, FIGS. 8-9, further attached to the trailing arm assembly **200**, is connected to the drive train of the terminal tractor in the same manner as a common rear axle on any terminal tractor, the rear axle **500** including a rear differential **520** attaching to the drive train and including brakes, with brake actuators **530** connected to the foundation brake components contained in the rear axle **500** typically used in terminal tractor rear axles.

A rear loading ramp **620** of the frame **600** of the terminal tractor is designed to accommodate the modular suspension system **10** by the inclusion of a tapered approach section **622** with a suspension mounting cross member **624** located to facilitate mounting of the spring means **270** or the preferred transverse leaf spring **274**. A recess **623** in the tapered approach section **622**, FIGS. 8-9, comprising a rear cross member plate **626** leading to the approach section **622**, directs a semi trailer king pin into the fifth wheel plate **300** when the lift arm assembly **100** is in a lowered position, with tail portions **301** of the fifth wheel plate **300** resting upon the fifth wheel rest weldment **269**, FIGS. 7-9.

Other possible embodiments of the spring means **270** would include longitudinal leaf springs, coil springs with a track bar or air springs with a track bar, but would not be as simply applied as the single transverse leaf spring **274.**

When the modular suspension system **10** is applied to the frame **600** of the terminal tractor,

five scenarios come into play. First, when the terminal tractor is unloaded and the fifth wheel plate **300** is fully lowered, FIG. 8, the modular suspension system **10** substantially isolates the frame from road shocks, using the elastomeric trailing arm bushings **210** and transverse leaf spring **274** as plural isolators. The tails **301** of the fifth wheel plate **300** rest upon the fifth wheel rest weldment **269** which attaches directly to the trailing arm assembly **200**, which is isolated from the frame **600** by the rear spring means **270** or the transverse leaf spring **274**, with the center **277** of the transverse leaf spring **274** attached to the spring mounting cross member **624** for lateral and vertical location and to provide vertical cushion. This maintains the fifth wheel plate **300** fully synchronized with the modular suspension system **10** and prevents unnecessary wear on the fifth wheel plate **300**, the lift arm assembly **100** and trailing arm assembly **200.** All rotational forces generated under acceleration and braking are distributed and minimized by the above isolation.

A second scenario is present when the terminal tractor is being loaded while the fifth wheel plate **300** in a lowered position, FIG. 8, but not shown under load, which commonly occurs when the terminal tractor is being hooked to a trailer. If the trailer has a very low coupler height, the tapered approach section **622** of the rear frame cross member **626** slides under the trailer, forcing the frame **600** slightly downward on the modular suspension system **10**, and lifting the trailer until the trailer slides onto the fifth wheel plate **300**. The weight of the trailer is passed through the rear frame crossmember **626**, the spring mounting crossmember **624**, the spring means **270** or the transverse spring **274** to the trailing arm assembly **200** and the rear axle **500.** Backing on under the trailer will effect coupling. The lift arm assembly **100** would then be lifted after coupling and prior to movement, leading to the third scenario below.

With the loaded trailer attached and the lift arm assembly **100** fully raised, the weight of the

trailer is carried through the fifth wheel plate **300**, the lift arm assembly **100**, lift cylinders **400**, trailing arm assembly **200** and the rear axle **500.** As much as 10% of the trailer weight could be carried froward to the elastomeric trailing arm bushings **210** and composite bushings **110** where it would then be carried to the frame **600.** In this scenario, nearly 95% of the load is carried by the modular suspension system **10** and not the terminal tractor frame.

Fourth, when the fifth wheel plate **300** is raised and the trailer is loaded during acceleration, the distribution of forces will depend on the torque being delivered to the rear axle **500.** For example, a 174 horsepower engine, generally supplied as an industry standard, under full throttle acceleration with a heavy load could generate torque in the range of 36,000 lbs/ft (based upon 458 lbs/ft x 2.43:1 torque multiplication x 3.58:1 reduction in low gear x 9.08:1 rear axle drive ratio.) Adding an additional rotational force of approximately 25% or another 9,000 lbs./ft for the inertia of the loaded trailer at 16" of lift height to the 36,000 lbs/ft yields approximately 45,000 lbs/ft, reduced proportionally by the length of the trailing arm assembly **200**, approximately 5 feet, for a gross weight yield of 9000 lbs/ft delivered to the elastomeric trailing arm bushings **210** at the center of the frame **600.** Without the modular suspension system **10**, the terminal tractor bucks or rises abruptly during acceleration. The modular suspension system **10** transfers the primary accelerating forces to the frame **600** of the terminal tractor at the center pivot bushing socket tube **610**, effectively balancing the effects of the accelerative forces between the front and rear suspensions and thus reducing the rise at front of the terminal tractor during acceleration and minimizing the resulting lift to the driver.

Fifth, when the fifth wheel plate **300** is raised and the trailer is loaded during deceleration, braking torque is the main factor in determining applied force. Under good repair and a hard braking application as much a 50,000 lbs/ft plus another 25% for kinetic energy of a loaded trailer, factoring

reduction due to the nominal 5 foot length of the trailing arm assembly **200**, a braking force of approximately 12,500 lbs/ft is presented at the elastomeric trailing arm bushing **210** at the pivot bushing socket tubes **610.** Without the modular suspension system **10**, the terminal tractor would experience a hard dive at the front of the terminal tractor. With the modular suspension system **10**, the terminal tractor and driver experience a significantly less movement, with the modular suspension system **10** more equally distributing the braking force by applying this force at the pivot bushing socket tubes **610** near the center of the frame **600**, thus balancing the application of force between the front and rear axles of the terminal tractor and reducing the dive reaction at the front of the frame **600** and on the operator.

Reducing stress and shock loading to the terminal tractor frame reduces wear to the terminal tractor and all of its components, including the electrical system, engine, drive train and front suspension, thus prolonging the useful life of the terminal tractor and lowering cost and frequency of repairs due to stress and shock loading.

While the invention has been particularly shown and described with reference to a preferred embodiment thereof, it will be understood by those skilled in the art that changes in form and detail may be made therein without departing from the spirit and scope of the invention.

What is claimed is: